

# Shoebox Geologist

Living with a **VOLCANO** in Your Backyard  
**MOUNT RAINIER**



Grade Level: 6–10

## Learner Objectives:

Students will:

- Learn about the types of deposits produced by volcanic processes
- Learn about the law of superposition
- Apply knowledge of geologic processes to create and interpret a model
- Measure and record data to create a stratigraphic column

**Setting:** Outdoors or in a tarped or uncarpeted classroom

**Timeframe:** 90 minutes (or two class sessions) plus 2 to 3 days drying time for models

*Interpreting a Stratigraphic Column of Books and Papers*—10 minutes

*Modeling Earth Events in a Shoebox*—40 minutes

*Interpreting Earth Events in a Shoebox*—40 minutes



## Living with a Volcano in Your Backyard- An Educator's Guide with Emphasis on Mount Rainier

Prepared in collaboration with the National Park Service

U.S. Department of the Interior  
U.S. Geological Survey

**General Information Product 19**

## Overview

Model depositional processes from volcanically active areas using sediments in a shoebox. Interpret geologic events from layers in a classmate's shoebox model and draw a stratigraphic column graphic.

### Before



### After



# Shoebox Geologist-continued . . .

## **Materials:**

### *Introducing Rock and Sediment Layer Interpretation*

- Class copies of “*Shoebox Geologist Recipes*” student page
- “*Layers at Sunrise Ridge on Mount Rainier*” graphic

### *Modeling Erosion and Deposition in a Shoebox*

- 6 to 8 copies of “*Shoebox Geologist Recipes*” student page
- 6 to 8 copies of “*Shoebox Geologist—Sequence of Events*” student page
- 6 to 8 copies of “*Shoebox Geologist—Interpretation of Events*” student page
- 2 to 4 tarps (for indoor use only)
- Pea gravel
- Medium to coarse sand
- Sawdust
- Potting soil
- Dry cement powder or rock dust
- 4 or more varieties of colored sand
- Soil
- Fine white sand
- Twigs
- Human artifacts (bottle caps, match sticks, string, etc.)
- 6 to 8 shoeboxes
- 18 to 24 containers for mixing sediments (plastic bags, buckets or large beakers work well)
- Disposable gloves for students
- Spoons for scooping rock materials
- Spray bottles with water

### *Interpreting Volcanic Events from Layers in a Shoebox Model*

- Copies of “*Shoebox Geologist-Recipes*” student page
- Copies of “*Shoebox Geologist—Interpretation*” student page
- 6 to 8 rulers
- 6 to 8 scissors

**Vocabulary:** Deposit, Law of Superposition, stratigraphic column

**Skills:** Measure, demonstrate, compare, interpret, observe, apply, analyze, conclude

## **Benchmarks:**

See benchmarks in Introduction.



## Teacher Background

Earth processes, such as volcanic events, floods, landslides and glaciers, frequently leave behind evidence of their passing in the form of layers known by geologists as **deposits**. By studying deposits of recent Earth events, geologists are able to look at older deposits and identify the processes that caused them.

One of the fundamental principles of geology is the **Law of Superposition**. This law states that layers that are younger will be deposited on top of layers that are older. This law is a guiding principle of studying rock and soil layers. The Law of Superposition helps geologists determine the relative ages of earth events.

Geologists often portray these deposits in a vertical drawing called a **stratigraphic column**. Drawing a stratigraphic column can help students visualize a sequence of earth events.

## Procedure

### What to do before class begins:

1. See “Materials” and “Recipes” on page 12 for list of items to collect and description of what volcanic deposits they represent.
2. Assemble each type of rock material in a bucket, or in bags. Label your materials for easy access and identification by students—tephra, lahar, forest floor, etc. You might choose to place a selection of materials in one-gallon bags, and deliver them to each student group. If you are conducting the activity in a natural setting, ask the students to collect and label materials.
3. Instruct students to collect “human artifacts” (i.e., paper clips, buttons, etc.), and to bring a shoebox from home.
4. The shoebox layers will remain more cohesive if you add powdered quick-drying cement such as Plaster of Paris, at a ratio of approximately four parts rock material to one of quick-drying cement. A light misting of water should be added by students using a spray bottle just after they create each layer in their shoebox. Test this before class to determine how much water students should spray on with the material that you have given to them. Tamping or pressing firmly after each layer will also help the layers to solidify. As an alternative to use of the cementing ingredient, use simple layers of different coors of sand—layers that hold together well and can be identified easily.

## **Interpreting a Stratigraphic Column of Books and Papers**

The Law of Superposition states that layers that are younger will be deposited on top of layers that are older. Illustrate this concept by having the class build a column of papers and books, followed by the drawing of a stratigraphic column on a projected transparency or board.

1. To illustrate the Law, create a stratigraphic column graphic as a class. Multiple students stack papers and books at one central location that is visible to all.
2. Afterwards, the class describes the events from first to last. Students verbally describe some characteristics of each book or paper layer. During this discussion draw and label the event sequence, from bottom to top, on an overhead transparency or board.
3. Instruct students to remove one or more books before the stratigraphic column graphic is finished. Ask if there is evidence that the event ever happened.
4. Discuss some of the geologic processes that might produce layers at Cascade volcanoes. Then, display the ***“Layers at Sunrise Ridge on Mount Rainier”*** graphic to show the class a true example of rock and sediment layers. Point out the different types of layers in the section. Refer students to the table on the ***“Shoebox Geologist Recipes”*** student page that describes the different layers produced by geologic processes.
5. Discuss gradual versus catastrophic processes and give examples: soils are formed by gradual processes; tephra desposits are deposited by a catastrophic process.



# Shoebox Geologist-continued . . .

## **Modeling Earth Events in a Shoebox**

Model the deposition and erosion of various geological processes using ingredients in a shoebox.

1. Conduct this activity outdoors or in a room free of carpets.
2. Place buckets or bags of materials and water on a resource table so that students can obtain them as needed.
3. Divide students into 4 to 5 person groups.
4. Each group requires a shoebox, containers for water (spray bottles) and for carrying materials to their work area, copies of “*Shoebox Geologist Recipes*” and “*Shoebox Geologist Sequence of Events*” student pages. Students write their group number on the “*Shoebox Geologist—Sequence of Events*” student page.
5. Students should work in groups to decide the type, order and thickness of layers that they wish to construct in their shoebox. Encourage and model discussion along the following lines: *“At the bottom of the box, I will make a stream bed. A thick lahar will flow over the top of the stream bed, followed by rocks from a pyroclastic flow, and a thin layer of volcanic ash. On top of that I will put a layer of rocks from a lahar, then two more layers of thick volcanic ash—each of different colors. Then, I will add rocks from another lahar, some human artifacts, another ash layer, and then forest floor on top.”*
6. Students list their chosen layers in sequence from oldest to youngest (bottom to top) on the “*Shoebox Geologist—Sequence of Events*” student page. On the “*Shoebox Geologist Recipes*” student page, students circle their necessary ingredients, and place numbers on the page margin to show the order in which ingredients are be added.
7. Place the “oldest” layer on the bottom of the shoebox and tamp or press firmly to solidify. Mist lightly with water to activate the Plaster of Paris. Continue layering the materials, pressing firmly, and lightly misting each layer according to the desired sequence of events. Be careful not to add too much water. The boxes should be damp but not dripping.
8. Allow shoeboxes to dry for 2 to 3 days.



# Shoebox Geologist-continued . . .

## **Interpreting Volcanic Events from Layers in a Shoebox Model**

Interpret the shoebox layers by drawing a graphical representation of the stratigraphic column.

1. After the shoebox models are dry, students exchange their model for that of another group.
2. Give each group a “*Shoebox Geologist—Interpretation of Events*” student page. Each group should also have at hand their “*Shoebox Geologist Recipes*” student page distributed previously.
3. Instruct students to cut open the sides of the boxes carefully, using scissors, making any notations about initial observation of geologic events on the back of the student page.
4. Measure the thickness of each layer with a ruler, and then record their observations on the “*Shoebox Geologist—Interpretation of Events*” student page.  
*Note: If the model is too dry and crumbly, use water from a spray bottle to dampen it.*
5. Instruct students to use the table from the “*Shoebox Geologist Recipes*” student page to identify the layers. Students should interpret the order of geologic events using the stratigraphic columns and the “Law of Superposition.”
6. Return the “*Shoebox Geologist—Sequence of Events*” student pages from the previous section to the appropriate groups. Direct students to compare their interpretations to the list of actual events from the group that constructed the model.
7. Discuss as a class why interpreting layers is important. What are some difficulties in interpreting layers? Which layers were gradually deposited and which were deposited catastrophically?





# Shoebox Geologist-continued...

## **Photo Instructions:**



### **1. Choose Ingredients:**

Choose types of ingredients and order of layers. Include vegetation and human artifacts.



### **2. Add layers to the box:**

Add ingredients in the order that your group has chosen.



### **3. Fill the box:**

Add layers that are easily distinguishable.



### **4. Tamp down layers:**

Tamping or pressing firmly after each layer will help them solidify.

# Shoebox Geologist-continued . . .



## 5. Cutting the box:

After box has dried—cut a slit in the front of the box.



## 6. Peeling back:

Slowly and carefully peel off the front and sides to reveal the layers.



## 7. Observe the layers:

Measure and analyze origin of layers.



# Shoebox Geologist-continued . . .

## ***Adaptations***

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- ◆ Stratigraphic columns can be created in a graduated cylinder or beaker.

## ***Extensions***

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### ◆ **Photograph Your Shoebox**

Take photographs of each opened shoebox and instruct students to label each layer using a computer graphics program.

### ◆ **Kitchen Layers in a Jar**

Make your own layered sequence out of kitchen ingredients. Use ingredients such as cornmeal, cinnamon, oatmeal, flour, decorative sprinkles, and different colors of sugar to represent volcanic deposits (lahars, tephra, lava) and glacial or stream deposits.

1. Fill a graduated cylinder or tall jar with layers of different ingredients. Add each ingredient so that layers are of different thickness. Each layer should contain material that looks similar to the type of deposit it represents.
2. Instruct students to write and apply labels of each layer with a piece of masking tape.
3. Instruct students to write a story about the series of events that occurred to deposit these layers.

### ◆ **Stratigraphic Columns from Other Regions?**

Use library or Internet research to find stratigraphic columns of other geologic regions. Discuss how they are alike or different from stratigraphic columns in volcanic landscapes.

### ◆ **Write a Geologic Story**

Instruct students to write the geologic story of the events that happened at the site of their shoebox geology.



# Shoebox Geologist-continued . . .

## ◆ Luscious Layers—build an edible model of Mount Rainier using simple kitchen products.

Conduct this activity as a teacher demonstration or in student groups. Prior to the class, bake three cake layers for your demonstration or for each student group. Assemble kitchen ingredients that represent a variety of eruptive products. For example, use cut and quartered cake layers as lava layers, crumbled cookies as loose rock layers deposited by pyroclastic flows, cocoa powder as tephra, canned whipped cream as glacier cover, and chocolate sauce as a lahar. Provide each group with a cookie tray, cake layers, and assembled kitchen ingredients, paper towels for cleanup, and plates and forks for eventual cake consumption. Build a stratovolcano by stacking ingredients into alternating layers. Take care to stack layers irregularly, as is typical of a stratovolcano. Remind students that most stratovolcanoes are not perfect cones. Pour chocolate sauce over the cake to illustrate a lahar. When the volcano cakes are completed, summarize the processes that build real stratovolcanoes, and review the Law of Superposition. Use a knife to carve out a section that exposes all layers, and then feed the cake to your volcano makers.

Simplify preparations by purchasing a frosted layer cake. Gently lift cake layers to add crumbled cookies and cocoa powder. Run the chocolate sauce lahar over it. Cut the cake open to expose the layers. As a cheaper alternative, stack pancakes instead of cake layers.



## Assessment

For assessment, review the stratigraphic columns and look for evidence of student recognition that each layer represents a geologic event. Students should be able to interpret the order of events by noting that the oldest evidence exists at the bottom while products of younger events are found at the top. Assess application to real—world situations by assigning interpretation of an additional ready-to-interpret geology shoebox. For older students assign an interpretation of layers at a local roadcut or stream cut in your community.

## References

- Cas, R.A.F., and Wright, J.V., 1987, Volcanic successions modern and ancient—a geological approach to processes, products and successions: Allen and Unwin, London, 528 p.
- Fisher, R.V., and Schmincke, H.U., Pyroclastic rocks: New York, N.Y., Springer-Verlag, 1984, 472 p.
- Scott, K.M., Vallance, J.W., and Pringle, P.T., 1995, Sedimentology, behavior, and hazards of debris flows at Mount Rainier, Washington: U.S. Geological Survey Professional Paper 1547, 56 p., 1 pl.
- Vallance, J.W., and Scott, K.M., 1997, The Osceola Mudflow from Mount Rainier: sedimentology and hazard implications of a huge clay-rich debris flow: Geological Society of America Bulletin, February, 1997, v. 109: no. 2, p. 143–163, 6 tables.
- Zehfuss, P.H., Atwater, B.F., Vallance, J.W., Brenniman, H., and Brown, T.A., 2003, Holocene lahars and their by-products along the historical path of the White River between Mount Rainier and Seattle: *in* Swanson, T.W., ed, Western Cordillera and adjacent areas: Boulder, Colo., Geological Society of America Field Guide 4, p. 209–223.



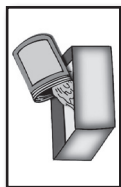
Refer to **Internet Resources Page** for a list of resources available as a supplement to this activity.

## Photo Credits

1. Layers at Sunrise Ridge on Mount Rainier, Photo by Greg Burtchard, National Park Service.



# Shoebox Geologist Recipes



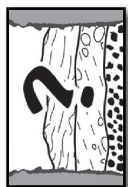
**Instructions:** Use this table to construct and interpret shoebox geologist models

Layers	Mechanisms	Materials in actual deposit	Recipe for deposit in shoebox
<b>TEPHRA</b> (Volcanic ash is fine-grained tephra)	Tephra falls from eruption plume or cloud	Fragments of rock exploded out of the volcano (some bubbly) White, gray, yellow, orange, and brown in color	Colored sand, coarse natural sand, cement dust, sawdust, small gravel
<b>LAHAR</b> (Volcanic mudflow)	Eruptions melt snow and ice; meltwater mixes with loose rocks and flows down river valleys	Boulders and cobbles in a mixture of water, mud, clay, dirt and tree debris	Mixture of dirt and gravel or crushed rock. Add just enough water to make it flow
<b>PYROCLASTIC FLOW</b>	Avalanche of hot, dry rocks capped by a cloud of rock dust and gases	Coarse to fine-grained rock	Mixture of sand and gravel
<b>STREAM GRAVEL</b>	Overlapping layers of well-sorted and rounded stones, gravel, sand, silt deposited in water	Overlapping layers of well-sorted and rounded stones, gravel, sand, silt	Gravel of variable sizes
<b>LAVA FLOW</b>	Lava erupts from volcanic vent and flows across surface of a volcano	Solid rock and often broken into large blocks	Mixture of fist-sized and smaller rocks
<b>LANDSLIDE or ROCKFALL</b>	Rocks accumulate as a fan-like pile that is narrow at the source and broad down slope	Boulders or large chunks of rock and dirt that have been displaced down slope	Clods of dirt or cobbles to represent large boulders
<b>FOREST FLOOR</b>	Long-term accumulation of decomposed plant material mixed with rock fragments	Partially decomposed needles and leaves from trees and smaller plants; rock fragments	Twigs, bark needles and leaves, garden soil
<b>HUMAN ARTIFACTS</b>	Litter remains from human occupation; may be buried by more recent volcanic layers	Stone tools, litter piles, and other evidence of old dwellings and eating areas	Bottle caps, paper, string, match sticks, etc.



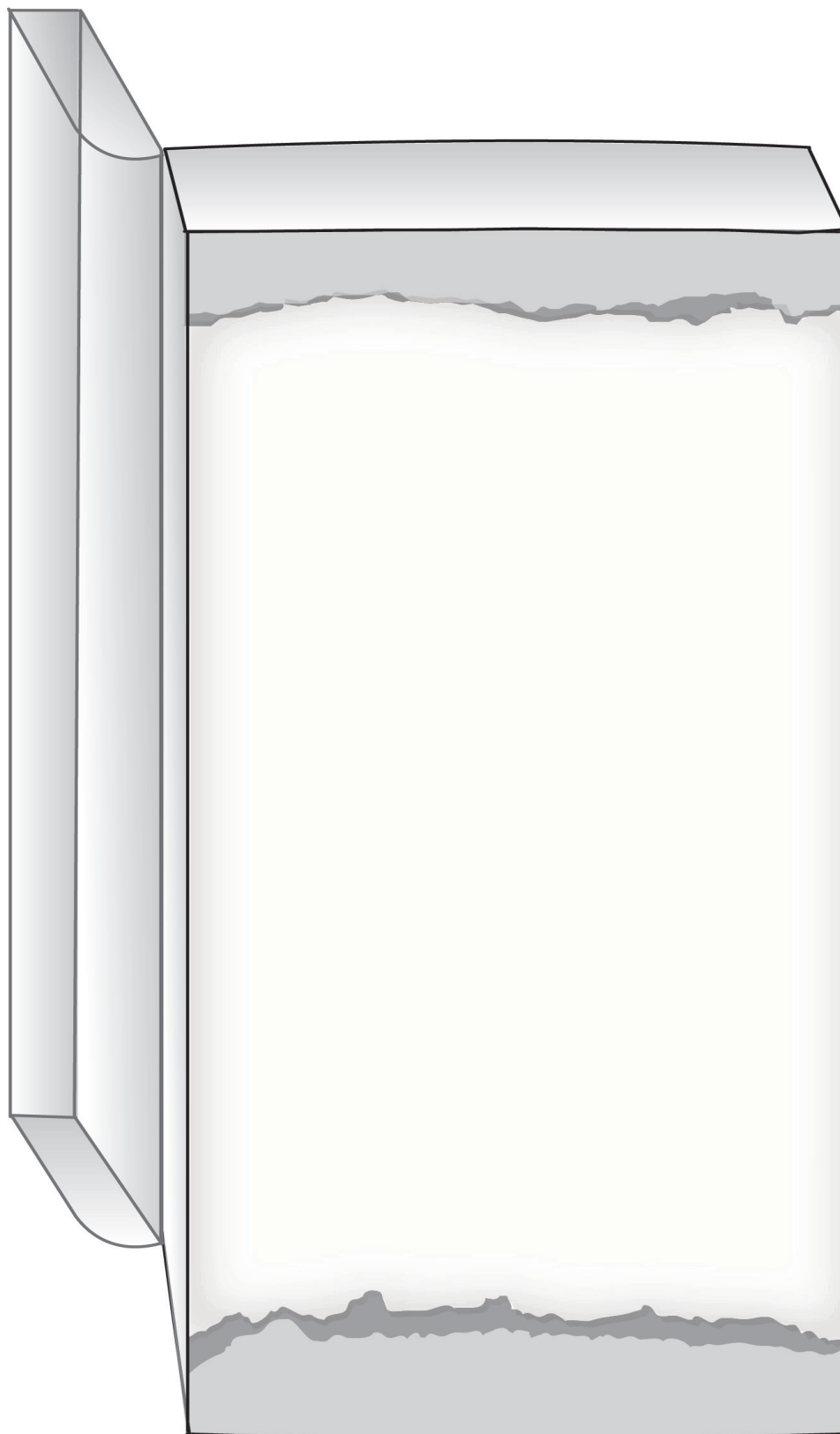
Team Names \_\_\_\_\_

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## Shoebox Geologist—Sequence of Events

**Instructions:** Record the series of geological events that you show in your model from oldest to youngest.







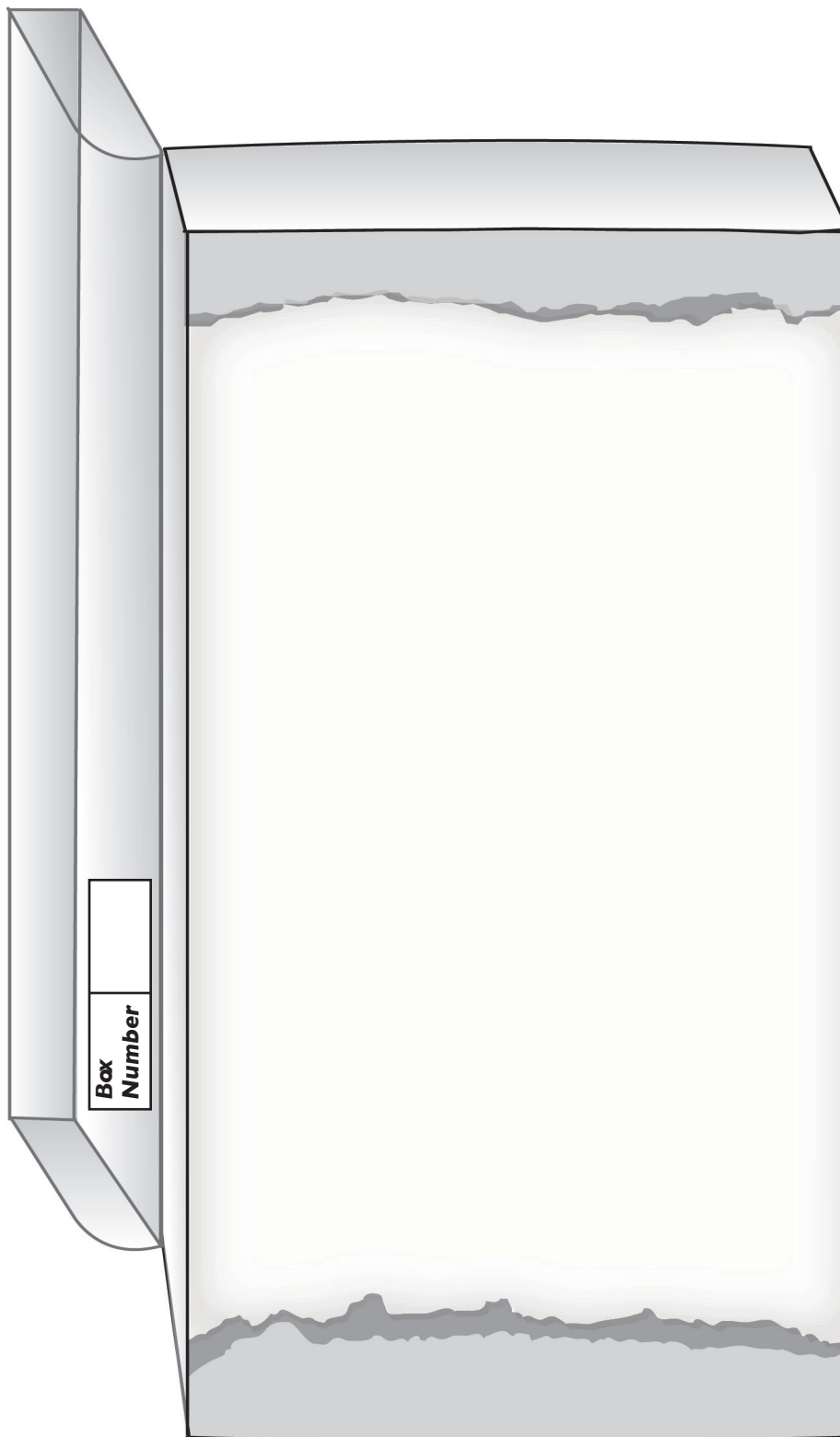
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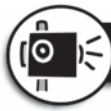
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## Shoebox Geologist—Interpretation of Events

**Instructions:** Draw the layers from the model you were given to interpret. Be sure to measure the thickness of each layer and accurately draw the layers in the rectangle below. Use shading and patterns to represent the different deposits. Label all layers in your stratigraphic column. On the back of the paper, describe the order of events. Which team's shoebox are you interpreting?





## Layers at Sunrise Ridge on Mount Rainier

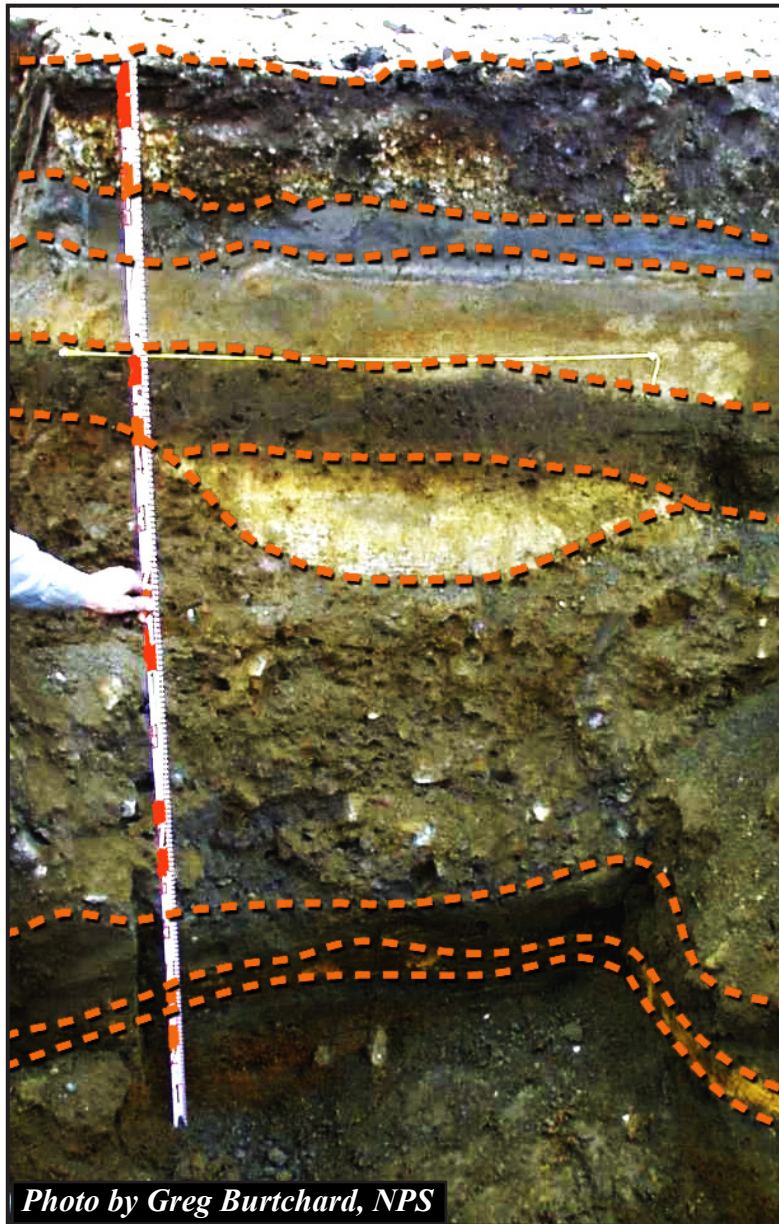


Photo by Greg Burtchard, NPS

Modern Ground Surface

Mount Rainier C-layer tephra  
~2,200 years ago

Mount St. Helen's P-layer tephra  
2,500 to 3,000 years ago

Mount St. Helen's Y-layer tephra  
~3,300 to 3,700 years ago

Old Soil

Mount Rainier F-layer tephra  
(in pocket), ~5,000 years ago

Possible Osceola Lahar  
~5,700 years ago

Old Soil

Ancient Mount Mazama O-layer tephra  
~7,700 years ago

Forest fire material in old soil  
~7,700 years ago

